Journal of Crops, Livestock and Pests Management
2(2)
Received: May 28, 2024
Accepted: July 3, 2024
Published: July 24, 2024

Evaluation of Carcass and Meat Quality Traits among Domesticated Rabbit Breeds Crosses in Western and North-rift Kenya

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Abstract

Rabbit farming has a lot of promise for producing high-quality meat, which may help with nutrition and poverty reduction. The current study sought to investigate the carcass and meat quality traits of domesticated rabbit (*Oryctolagus cuniculus*) (L) crosses. The local breeds included in the study were from Kenya's Western and North-rift areas. On-site research was carried out in the rabbitry unit of the University of Eldoret (UoE). Rabbits were reared in cages with standard specifications. The F1 rabbits were sacrificed when they were at roasting age in the University of Eldoret Laboratory. The weight of the carcass, head and internal organs, pelt and tail were taken and recorded. In preparation for sensory evaluation of domestic rabbit crosses meat a total of twenty-two (22) panelists within age group of 18 to 25 years were randomly sourced from the school of consumer science, food science department. A five-point hedonic scale was used to assesss sensory evaluation of domestic rabbits' meat across the breed crosses. Least square means for carcass and its parts' weight as well as sensory qualities were estimated using the GLM procedure of SPSS version 20. Live weights (g) before fasting were significantly high in NZW*SF (2319±164) and low in NZW*FG (2188±156). In terms of hot carcass weight, NZW*R (1083±96.0) cross had significant higher weight in comparison to other crosses. Giblets- liver heart and kidneys weight did not differ significantly among crosses irrespective of NZW*Pr (89.5±7.65) which differed. A higher dressed weight of the head was recorded for NZW*SF (147±16.2) which was non significantly different with other crosses ($p>0.05$). Primal cut up parts of rabbit crosses carcasses were established where they did not differ significantly with crosses. The ranking of the flavour, tenderness, juiciness, texture, colour as well as acceptability of meat from New Zealand cross with other breeds was not statistically significant ($P>0.05$). In conclusion various carcass characteristics weights as well as sensory traits did not significantly differ across the rabbit crosses. This could be due to the fact that the rabbits were kept in the same environment, fed with the same amount and type of feeds. The ranking of the flavor, tenderness, juiciness, texture, colour as well as acceptability of meat from New Zealand cross with other breeds was not significant irrespective of general acceptability ranked high in NZW*Sf. Research recommends more work to be done to compare the rabbit crosses with pure breed in terms of carcass characteristics. Additionally, effects of feed distribution mode, management, gender and age need to be tested to ascertain their influences in carcass characteristics. Similarly, more work needs to be done to compare the crosses meat organoleptic characteristics with those of pure breed.

Keywords: *Oryctolagus cuniculus,* carcass, meat quality, farming

Journal ISSN: 3005-2181

Article DOI: https://doi.org/10.69897/joclipm.v2i2.130

Issue DOI: https://doi.org/10.69897/joclipm.v2i2

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Funding: The author received no financial support for the research, authorship and/or publication of this article.

Data Availability Statement: The authors confirm that the data supporting the findings of this study are available within the article [and/or] its supplementary materials.

Competing interests: The authors declare no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Introduction

Domesticated rabbits are descendants of the European wild rabbit*, Oryctolagus cuniculus* (Johansson *et al*., 2015). Rabbit keeping for commercial purposes has lately gained popularity in food security and income generation (Sergon *et al*., 2018). Nowadays, rabbits are produced to some extent in all nations across the world, either for economic uses such as meat production or as pets (Alves *et al*., 2015; Ben Larbi *et al*., 2014). Italy, France, and Spain are the largest producers in Europe, where rabbit meat is seen as a more cost-effective alternative to meat from bigger cattle. From 2006 to 2016, global rabbit meat output climbed by 13% (Ballan *et al*., 2022; Cullere & Dalle Zotte, 2018; Nasr *et al*., 2017a) more so in Africa. In European countries rabbit production is decreasing while in Africa and America the production has been relatively constant in recent years (Elamin *et al*., 2012; Karikari & Asare, 2009; Nasr *et al*., 2017a; Rödel, 2022). Kenya is a developing country with a significant population living in rural areas and relying on agricultural production as a primary source of income. Rabbit production is further hampered by a lack of parent breeding stock, high commercial feed costs, and farmers' restricted access to scientific information (Cherwon, Wanyoike & Gachuiri, 2020; Wambugu, 2015).

The main traits of economic importance in rabbit production are feed conversion rate, litter size, and carcass yield (Macias-Fonseca *et al*., 2021; Nasr *et al*., 2017a). In rabbit farming, meat quality is the most important aspect to consider (Apata *et al*., 2012). All meat quality is described by its physical appearance, chemical components, and sensorial qualities, as the utmost critical attributes for the final animal protein consumer (Macias-Fonseca *et al*., 2021; Nuamah *et al*., 2019; Wanjala, 2015). The latter, varies directly by the weight of the carcass and, the possibility of predicting its value, would produce valuable information to guarantee the viability and sustainability of the production system (Cullere & Dalle Zotte, 2018; Karikari & Asare, 2009).

Rabbit meat is usually considered as low fat meat compared with red meats (Dalle Zotte & Paci, 2013). However, information available from chemical composition of rabbit meat is extremely variable, lipid composition ranging from 3.6% (Nasr *et al*., 2017a) to 8% (Hungu, 2011). This could be due to the study of different parts of the carcass in the different investigations. Chemical meat composition is studied in the Longissimus dorsi (LD) muscle, where colour (Apata *et al*., 2012; Nasr *et al*., 2017b; Nuamah *et al*., 2019), collagen (Hungu, 2011), texture (Daszkiewicz & Gugołek, 2020; Serem et al., 2013; Szendrő *et al.,* 2012) and sensorial analysis (JEHL & JUIN, 2001) are often measured. In other cases, the meat comes from the dissection of the hind leg, previously dissected to estimate the meat to bone ratio of the carcass. Moreover, carcasses analysed could be from animals of different weight and age (Daszkiewicz & Gugołek, 2020; Serem *et al*., 2013; Szendrő *et al*., 2012), breed, sex or degree of maturity (Daszkiewicz *et al*. (2012).

The ranking of the flavor, tenderness, juiciness, texture, colour as well as acceptability of meat from New Zealand cross Hungu (2011), with other breeds was not significant irrespective of general acceptability ranked high. Fadare (2015), highlighted the importance of weight and food restrictions at a certain age that in influencing on rabbit meat quality impacting greatly op consumer acceptability. Similarly, Daszkiewicz & Gugołek, (2020), Serem *et al*. (2013) and Szendrő *et al*. (2012), noted that production systems be it intensive and extensive, influences meat quality and quantity of rabbits. Fadare (2015), in addition highlighted the importance of stress in its influence in pH, color or darkness as well as tenderness of rabbit meat. In another study, a cross between New Zealand white and Palomino brown produced meat with least flavor (Fadare, 2015). Currently, no research comparing carcass and meat quality traits among domestic rabbit crosses exists in Kenya. Thus, the objective of this research was to compare carcass and meat quality traits as well as organoleptic characteristics of the domesticate rabbit breed in Western and North Rift areas of Kenya.

Materials and methods

Study area

The parent rabbits were from Kenya's Western and North Rift areas. The research was carried out on-site at the University of Eldoret (UoE) Farm (rabbitry division), Animal Science, and the Biological Laboratory in Uasin Gishu County, Kenya, at latitude 0°34'26.21"N and longitude 35°18'11.01"E. Rainfall in the region is unimodal, with annual averages ranging from 1000mm to 1520mm. Long rains occur from March to August, whereas brief rains occur from November to December. From January through March, there is a significant dry spell. The temperature at the location ranges from 23.6oC during the day to 9.6oC at night (Barasa et al., 2015).

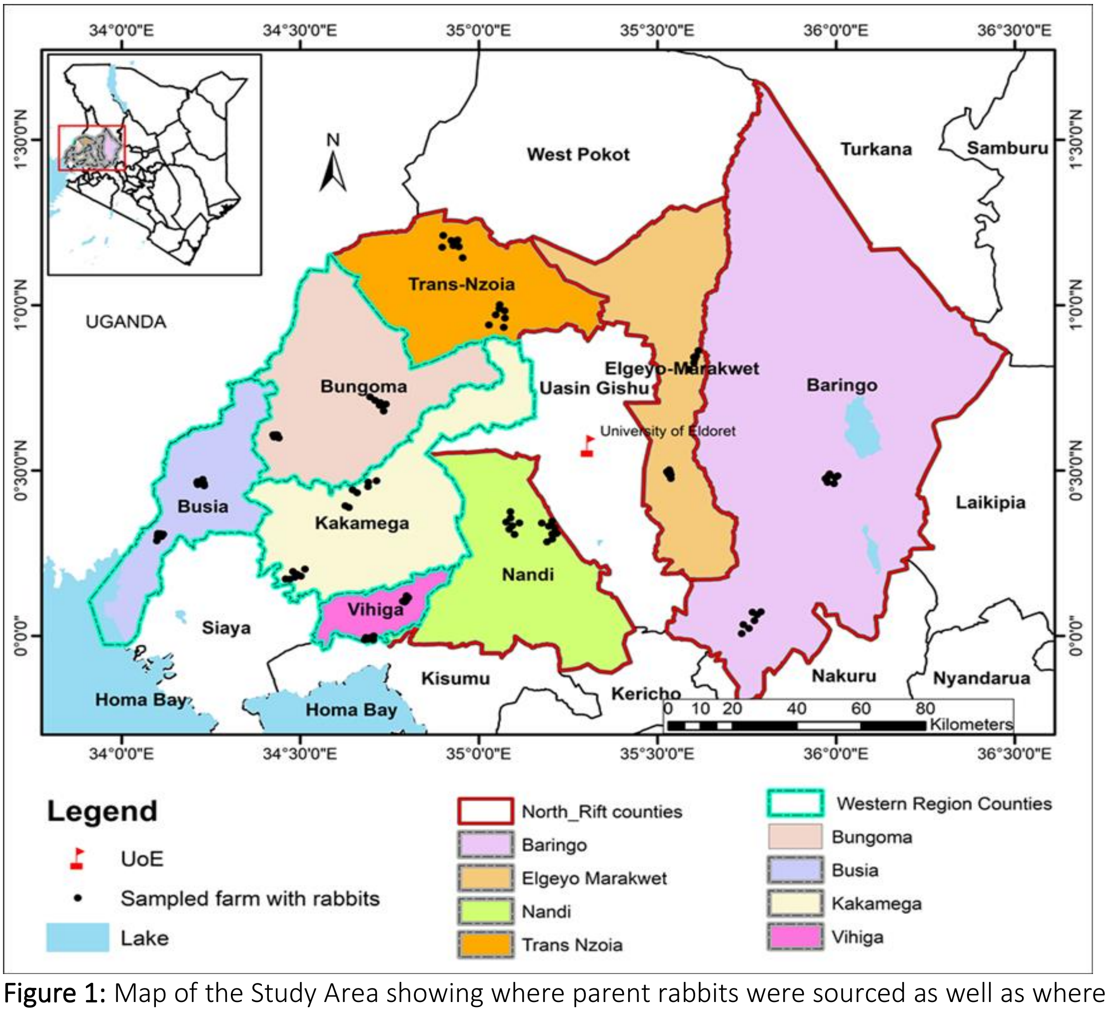

Figure 1: Map of the Study Area showing where parent rabbits were sourced as well as where experiment was carried out

Source: Author, 2022

Research design

The exploratory research strategy was used in the study to collect the required data. This was used to locate rabbit producers in the surrounding areas. The Cochran technique was used to calculate sample size for an unknown population, yielding a sample size of 126.

$$n_0 = \frac{Z^2 pq}{e^2}$$

e	Margin of error
p	Population proportion
z	Use Z Table

Sampling procedures and sample selection of domesticated rabbit breeds

The study focused on 126 rabbit producers. Before sampling, the population was separated into clusters (Western and North-Rift areas) for stratified and systematic sampling. The areas were chosen because of their various agro-climatological zones, which were considered to affect the phenotypic of the country's rabbit breeds. Snow balling sampling and chain referral sampling were used to collect parent rabbit does and bucks from farmers in Kenya's Western and North Rift regions. The rabbits chosen were from a random group of five- to six-month-old rabbits. For each breed, one or two individuals were obtained from farmers at the prevailing market price. The identified breeds were brought to the rabbitry division of the University of Eldoret to be taken care of.

Animals housing, feeding and health management

A foundation population of 24 females and 8 male adult local rabbits were chosen from the 126 rabbits gathered based on their divergent level of genetic variety. One male and three female pure breed New Zealand whites were obtained from the KALRO Research Station. To avoid breeding rabbits from various localities, these animals were randomly placed into groups of three does and one buck. A total of two hundred and sixteen (216) kittens were generated in the first generation as a result of mating (F1). F1 generation mating was avoided.

To avoid stress, fighting, and harm, sufficient chambers measuring 18x24x30 inches were supplied for the rabbit breeds as standard criteria for does and bucks (Clauss & Hatt, 2017). Each rabbit breed was kept separately in all-wire steel cages with a gutter to a slatted floor designed to collect feces and pee easily. They were given free access to water and fed twice daily at 08:30 and 15:30 h. The diet was a uniform meal made up of 40% pellets and 60% hay. The animals' general health, cleanliness, and husbandry methods were all taken care of. Before placing the rabbits in the cages, the rabbit home and cages were properly cleaned and disinfected, and routine hygiene was performed. Feeders were made from earthen bowls.

Slaughter and carcass yield measurements

The rabbits were sacrificed when they were at roaster age, with an average slaughter weight of 2.8±0.13 kg. Before slaughtering, the rabbits were tagged, fasted for 12h and weighed to determine the final live weight. The fur was removed by scalding. The rabbits were sacrificed in the University of Eldoret Laboratory. They were first held firmly by the back legs and head, followed bending the head backward with a strong, abrupt pull to dislocate the neck. To bleed the carcass, severing of the carotid arteries and jugular veins was done. During the dissection operations, the World Rabbit Science Association (WRSA) recommendations provided by Mondin *et al*. (2021) were followed. Individual weights of skin, feet and paws, sexual organs, urinary bladder, and whole gastrointestinal system were taken. The bodies were weighed 30 minutes after slaughter (hot carcasses - HC), then chilled for 24 hours at +4 °C in a ventilated environment. After 24 hours of chilling, the carcasses (CC) were weighed. HLTTO, the skull, the liver, and the kidneys were removed from each corpse to create the reference carcasses (RC), which contained the meat, bones, and fat deposits. For weights' assessment of different organs, the intestines (viscera) were separated with care so as to reduce tear into intestines (both small and large), liver, bile gland spleen, pancreases and kidneys.

Weights were taken for each part separated from the viscera and percentage weight to hot carcass weight calculated. The hot dressed carcass was weighed before chilling 24 hours in a temperature on -4^0 C. After chilling, primal cuts were made which included loin, chest, hind legs and their weight taken separately. The thigh muscles from the thigh legs were later used for sensory evaluation and laboratory analyses. The weight of the carcass, head and internal organs, pelt and tail were taken and recorded.

Sensory evaluation of domestic rabbits' crosses meat

In preparation for sensory evaluation of domestic rabbit crosses meat a total of twenty-two (22) panelists within age group of 18 to 25 years were randomly sourced from the school of consumer science, food science department. To void gender biasness, equal number of male and female student were used in this study. Care was chosen to 'knock out' individual with underlying respiratory diseases such as cough, common cold and tuberculosis. Choosing and training of the candidates observed British Standard Institution guidelines to evaluate the products (Lawson *et al*., 2014). The rabbit meat from thigh muscles were defrosted, sliced into small pieces (about 2cm) and grilled in a 70°C electric oven (Turbofan, Blue seal, UK). The cooked pieces were then enveloped with oblique aluminium foils and later presented to panelists alongside bottled water and a tuscan bread that served as neutralizers between products from different rabbit crosses. A five-point hedonic scale was used to evaluate sensory evaluation of domestic rabbits' meat across the breed crosses focusing on meat flavor, tenderness, juiciness, acceptability and colour.

Statistical analysis

Least square means for carcass and its parts weight were estimated using the GLM procedure of SAS version 9.1.3 (SAS Institute Inc., Cary, NC, USA). The model used was $Y_{ij}=\mu+P_i+e_{ij}$, where Y_{ij}=any observation of rabbit within ith populations (P), μ=overall mean, P_i=the effect of the populations, i=1, 2, and 3, and e_{ij}=the random error. Significant differences between the populations were defined by Duncan test. The carcass yield, that was carcass weight as a percentage of Slaughter weight (SW) was represented as either the hot carcass (HC) or chilled carcass (CC) weights, and the carcass trait and organ ratios to both the SW and CC weights were determined as needed. Computations were carried out using the general linear model (GLM) procedure of SPSS 20 (IBM, USA).

Results

Carcass characteristics of rabbit crosses

Live weights (g) before fasting were insignificantly high in NZW*SF (2319±164) and low in NZW*FG (2188±156). Fastened live weight (pre slaughter weight) of domestic rabbit crosses) followed the same trend (Table 4.19). Fasting loss did not significantly differ among the crosses. The weight after bleeding was determined and the highest non-significant weight ($p>0.05$) was recorded for NZW*SF (2203±206) with the lowest recorded in NZW*FG (2066±151). In terms of hot carcass weight, NZW*R (1083±96.0) cross had insignificant higher weight in comparison to other crosses. Giblets- liver, heart and kidneys weights did not differ among crosses irrespective of NZW*Pr (89.5±7.65) having a higher weight. A higher dressed weight of the head was recorded for NZW*SF (147±16.2) insignificantly different from other crosses ($p>0.05$). Similarly, total edible parts, dressing yield, carcass %, carcass with giblets and dressed head, % inedible parts, pelt, feet and tail, spleen, lungs and trachea, inedible parts of the head and the ratio between inedible and edible parts did not differ among the crosses as illustrated in Table 1.

Table 1: Carcass characteristics of rabbit crosses (Mean ± SE)

Parameters	NZW*FG	NZW*SF	NZW*Dr	NZW*R	NZW*Pr	NZW*KARLO
Live weight before fasting, g	2188 ±161	2319±214	2253 ± 128	2267 ± 195	2273 ± 284	2270 ± 164
Fasted Rabbit weight (g) before slaughter	2129 ± 156	2270 ± 213	2200 ± 127	2218 ± 194	2218 ± 280	2218 ± 163
Fasting loss, g	58.3±5.87	49.2 ± 2.01	48.8 ± 1.75	48.3 ± 3.07	55.0 ± 5.00	51.7 ± 2.97
	(2.65±0.13)	(2.25±0.21)	(2.45±0.13)	(2.26±0.20)	(2.63±0.28)	(2.44±0.17)
Weight after bleeding, g	2066 ± 151	2203 ± 206	2135 ± 123	2154 ± 187	2158 ± 272	2156 ± 158
Edible parts						
Hot carcass, g	1012 ± 72.1	1070 ± 114	1041 ± 64.9	1083 ± 96,0	1050 ± 138	1067 ± 80.1
	(47.6±0.22)	(46.9±0.92)	(47.2±0.46)	(48.9±1.34)	(47.1±0.68)	(48.0±0.76)
Giblet – liver, heart and kidneys, g	81.0 ± 7.69	87.8 ± 8.41	84.4 ± 5.53	84.8 ± 5.64	89.5 ± 7.65	87.0 ± 4.58
	(3.77±0.11)	(3.89±0.15)	(3.83±0.09)	(3.88±0.16)	(4.28±0.47)	(4.08±0.25)
Dressed head, g	127 ± 5.02	147 ± 16.2	137 ± 8.65	143 ± 13.5	134 ± 11.8	139 ± 8.65
	(6.07±0.33)	(6.70±0.92)	(6.38±0.48)	(6.49±0.29)	(6.27±0.36)	(6.38±0.22)
Total edible parts, g	1220 ± 83.4	1305 ± 122	1262 ± 71.5	1311± 113	1274 ± 155	1292 ± 91.7
	(57.4±0.33)	(57.5±0.47)	(57.4±0.27)	(57.3±2.13)	(57.7±0.61)	(57.5±1.06)
Dressing yield						
Carcass, %	47.6 ± 0.22	46.9 ± 0.92	47.2 ± 0.46	48.9 ± 1.34	47.1 ± 0.68	48.0 ± 0.76
Carcass with giblet, %	51.9 ± 0.90	50.8 ± 0.88	51.4 ± 0.62	52.8 ± 1.44	51.4 ± 0.43	52.1 ± 0.74
Carcass with giblet and dressed head, %	57.1 ± 0.25	57.5 ± 0.33	57.3 ± 0.26	59.3 ± 1.59	57.7 ± 0.61	58.5 ± 0.85
Inedible parts						
Blood, g	63.2 ± 4.29	67.0 ± 7.17	65.1 ± 4.03	63.9 ± 6.90	60.5 ± 8.29	62.2 ± 5.17
	(2.97±0.05)	(2.85±0.12)	(2.91±0.06)	(2.8 ±0.08)	(2.70±0.07)	(2.78±0.05)
Pelt, g	179 ± 14.4	205 ± 20.9	192 ± 12.7	214 ± 27.6	195 ± 24.3	205 ± 17.7
	(8.37±0.10)	(9.03±0.42)	(8.70±0.23)	(9.47±0.56)	(8.93±0.46)	(9.20±0.35)
Feet and tail, g	80.0 ± 1.50	89.5± 3.07	84.8 ± 2.17	92.7 ± 4.64	82.8 ± 4.38	87.8 ± 3.39
	(3.88±0.34)	(4.12±0.42)	(4.00±0.26)	(4.31±0.34)	(4.17±0.70)	(4.24±0.37)
Spleen, g	1.67 ± 0.25	2.33 ± 0.36	2.00 ± 0.23	1.83 ± 0.10	1.75 ± 0.33	1.79 ± 0.17

	(0.08±0.01)	(0.11±0.01)	(0.09±0.01)	(0.08±0.002)	(0.08±0.01)	(0.08±0.004)
Lungs and trachea, g	17.5 ± 1.67	18.3 ± 2.20	17.9 ± 1.32	14.8 ± 1.25	18.3 ± 1.82	16.6 ± 1.18
	(0.82±0.03)	(0.80±0.04)	(0.81±0.02)	(0.67± 0.23)	(0.86±0.08)	(0.77 ± 0.05)
G.I. tract full, g	249 ± 27.2	255 ± 15.7	252 ± 15.0	268 ± 11.3	245 ± 18.17	257 ± 10.8
	(11.5±0.64)	(11.4±0.39)	(11.5± .36)	(12.5± 0.90)	(11.7±1.00)	(12.1± 0.65)
Inedible parts of head, g	74.8 ± 4.85	88.83± 12.8	81.8 ± 6.84	76.2 ± 7.89	72.3 ± 9.70	74.3 ± 5.99
	(3.54±0.11)	(3.84± .22)	(3.69± .13)	(3.41 ± 0.18)	(3.30±0.22)	(3.35± 0.14)
Total inedible parts, g	675 ± 44.8	726 ± 57.2	703 ± 34.1	732 ± 55.2	673± 57.4	702± 39.0
	(31.8±0.38)	(32.2±0.69)	(32.0±0.38)	(33.3±0.92)	(31.6±2.05)	(32.4± .10)
Inedible: edible	1: 1.82 ± 0.02	1: 1.79 ± 0.04	1: 1.80 ± 0.02	1: 1.79 ± 0.08	1: 1.86 ± 0.10	1: 1.82 ± 0.06

NZW- New Zealand white, R-rex, FG-Flemish giant, KARLO-Kenya Agricultural Research and Livestock Organisation, SF- silver fox, P- Palomino, D-Dutch.Numbers in the parenthesis are in mean grams of live weight before slaughter (fasted weight). Figures in parenthesis indicate weight of organs in percentage (%) of live weight before fasting.

Table 2: Primal cut-up parts of rabbit crosses carcass (Mean ± SE)

	NZW*FG	NZW*SF	NZW*Dr	NZW*R	NZW*Pr	NZW*KARLO
Hot carcass weight, g	1012.67± 72.14a	1070.56± 114.53b	1041.45± 64.98ab	1083.85± 96.05c	1050.62± 73.45a	1067.36± 80.15b
Two shoulders, g	146.24 ± 14.69a	152.32± 17.72ab	147.21 ± 13.81a	160.44 ± 17.27c	149.32 ± 16.45a	165.71 ± 18.26c
	(14.43± 4.21)	(14.21± 2.52)	(14.12± 3.28)	(14.77± 2.19)	(14.19± 3.00)	(15.46± 2.88)
Thorax, g	218.67± 22.44a	222.64± 22.34ab	227.76 ± 22.11ab	216.99 ± 19.33a	215.66 ± 20.13a	209.56± 19.89c
	(21.54± 2.56)	(20.75± 2.33)	(21.81± 3.21)	(19.94± 2.87)	(20.48± 2.63)	(19.53± 3.56)
Loin, g	321.11± 19.10a	319.09± 26.23a	339.56 ± 31.56ab	351.87 ± 29.60c	321.42± 32.01c	318.36± 28.09c
	(31.5± 0.69)	(29.8± 1.32)	(30.7± 0.76)	(33.3± 1.01)	(29.7± 1.44)	(31.5± 0.99)
Two legs, g	313.02± 23.84a	364.35 ± 43.12b	339.65 ± 24.71c	344.59 ± 35.06c	352.24 ± 54.79b	348.56± 31.04bc
	(30.93± 2.29)	(34.02± 3.13)	(32.56± 3.56)	(31.76± 4.84)	(33.52± 3.74)	(32.61± 3.76)
Cutting loss, g	14.21± 1.23a	13.34± 1.56a	12.00 ± 2.86a	12.78± 3.81a	13.26 ± 2.99a	27.55± 4.02b
	(1.38± 0.98)	(1.21± 0.95)	(1.15± 0.56)	(1.11± 0.22)	(1.241± 0.61)	(2.53± 0.33)

NZW- New Zealand white, R-rex, FG-Flemish giant, KARLO-Kenya Agricultural Research and Livestock Organisation, SF- silver fox, P- Palomino, D-Dutch.Figures or numbers in the bracket indicate mean % and SE of hot carcass weight.

Table 3: Meat bone ratio of rabbit crosses carcass (Mean ± SE)

	NZW*FG	NZW*SF	NZW* Dr	NZW*R	NZW* Pr	NZW* KARLO
Weight of two hind legs (g)	313.02±23.8	364.35 ± 43.1	339.65 ± 24.7	344.59 ± 35.0	352.24 ±54.7	348.56 ± 31.0
Weight of one hind leg (g)	156.50±14.91	182.00±17.4	169.50±15.62	172.00±13.41	176.00±14.21	174.00±16.31
Muscle weight (g)	131.70±12.11	155.00±13.21	144.50±14.28	145.58±15.44	149.41±16.02	149.08±13.51
Bone weight (g)	24.80±1.99	27.00±2.31	25.00±2.00	26.42±3.10	26.59±1.96	24.92± 2.51
Meat bone ratio	5.31	5.74	5.78	5.51	5.62	5.98

NZW- New Zealand white, R-rex, FG-Flemish giant, KARLO-Kenya Agricultural Research and Livestock Organisation, SF- silver fox, P- Palomino, D-Dutch.

Table 4: Influence of domestic rabbit breed crosses on the organoleptic properties of meat

Organoleptic	NZW*R	NZW *FG	NZW *KARLO	NZW *SF	NZW*Pr	NZW*Dr	F	Sig.
Meat Flavour	6.16± 2.46	6.40± 2.67	6.45± 2.34	6.72± 2.41	6.04± 2.66	6.22± 2.47	0.459	0.807
Meat Tenderness	6.55± 2.08	6.78± 1.85	6.74± 2.14	6.80± 2.19	5.98± 2.85	6.12± 2.44	1.228	0.296
Meat Juiciness	5.89± 2.61	6.12± 2.63	6.44± 2.51	7.00± 2.26	5.96± 2.71	6.44± 2.19	1.303	0.263
Meat Texture	6.74± 2.21	6.71± 1.95	6.78± 2.24	6.98± 1.96	6.27± 2.62	6.31± 2.63	0.758	0.581
Meat Acceptability	6.53± 2.69	6.76± 2.69	7.08± 2.27	7.22± 2.29	6.43± 2.82	6.86± 2.32	0.71	0.616
Meat Colour	1.87± 0.74	2.10± 1.01	2.24± 1.01	2.23± 0.99	2.47± 1.03	2.22± 0.90	1.711	0.132

NZW- New Zealand white, R-rex, FG-Flemish giant, KARLO-Kenya Agricultural Research and Livestock Organisation, SF- silver fox, P- Palomino, D-Dutch.

Primal cut-up parts of domestic rabbit crosses carcass

Primal cut up parts of rabbit crosses carcasses were established. For the initial hot carcass weight, NZW*SF (1070.56±114.53), NZW*R (1083.85±96.05) and NZW*KARLO (1067.36±80.15) had the highest weight significant different weight in comparison with other crosses as illustrated in Table 4.20. NZW*R (160.44 ± 17.27) and NZW*KARLO (165.71 ±18.26) had the highest weights of two shoulders significantly (p<0.05) different with others crosses. Thorax weight of NZW*KARLO was significantly low in comparison with other crosses (p<0.05) as illustrated in Table 4.20. NZW*R (351.87 ± 29.60), NZW*Pr (321.42±32.01) and NZW*KARLO (318.36±28.09) had the highest mean loin weight in comparison with the other crosses while NZW*Pr (364.35 ± 43.12) and NZW*SF (352.24±54.79) had higher mean leg weights as illustrated in Table 2.

Meat bone ratio of rabbit crosses carcass

Hind leg muscle (g) was determined for all crosses. For the weight of the two hind legs, NZW*SF (364 ± 43.1) had insignificant higher weight (p>0.05) followed by NZW*Pr (352.2 ±54.7) while NZW*FG (313±23.8) had the lowest weight. Similarly, NZW*SF (182.00±17.4) had insignificantly higher with of one hind leg when compared with other crosses. Muscle weight did not differ among the crosses (p>0.05) irrespective of NZW*Pr having the weight of 26.59±1.96 in comparison with that of NZW*FG (24.80±1.99). Insignificantly higher bone ratio was recorded in NZW*KARLO (5.98:1) followed in NZW*Dr with a ratio of 5.78:1 while NZW*FG had the lowest ratio of 5.31:1 as illustrated in Table 3.

Influence of domestic rabbit breed crosses on the organoleptic properties of meat

The ranking of the flavour, tenderness, juiciness, texture, colour as well as acceptability of meat from New Zealand cross with other breeds was not statistically significant (P>0.05). NZW*Pal meat was ranked high in Texture (6.74±2.21), while NZW*Fg was ranked high in tenderness (6.78±1.85). Ranking of color was high in NZW*P (2.47±1.03) and low in NZW*R (1.87±0.74). General acceptability was ranked high in NZW*Sf (7.08±2.27) (Table 4).

Discussion

Carcass characteristics of rabbits' crosses

The findings indicated that various carcass characteristics including; live weight (before domestic rabbit fasting), pre-slaughter loss weight, weight after bleeding, edible parts weights, hot carcass weight in g, dressed head, liver, lungs, kidneys weight, total edible parts, dressing yield, carcass with giblet, carcass with giblet and dressed head, inedible parts, blood, pelt, feet and tail, spleen, lungs and trachea, gastro-intestinal tract full, inedible parts of head, total inedible parts weights before fasting was not significantly different across the rabbit crosses. This could be due to the fact that the rabbits were kept in the same environment, fed with the same amount and type of feeds.

The recorded average slaughter weight of New Zealand White rabbits crosses were in line with those of Nuamah *et al*. (2019), who indicated that in general, breed and sex do not significantly affect rabbit crosses' traits. The results obtained are similar to those reported by Macias-Fonseca *et al*., (2021), who registered a slaughter weight of 1998g for new Zealand breeds showing the importance of heterosis in the crossbreeding of rabbits. Meanwhile, according to Nuamah *et al*., (2019), the type of feed offered to the animals has statistically significant effects on the rabbit crosses' carcass parameters. The findings concur with those of Nasr *et al*., (2017), that rabbit crosses' carcass traits are influenced by the adult weight at slaughter, farming practices and the maturity of rabbits at the age of slaughter. They also noted that it was true only in a few cases where significant differences were observed between crosses.

In another study by Macias-Fonseca *et al*., (2021), evaluated characteristics of carcass in ascertaining productive performance was not influenced by gender of Californian and New Zealand white rabbits and their crosses. On the other hand, Khan *et al*., (2018) highlighted influences of sex on the weights of the carcass at slaughter weight of more than 2.5 kg.

Domestic rabbit primal carcass cut-up parts

Primal cut up parts of rabbit crosses carcasses did not differ significantly among the crosses. This could be explained by the fact that environment in which the crosses were brought was the same. This concurred with the findings of Ludwiczak *et al*. (2016), the type of feed as well as environmental conditions offered to the animals has statistically significant effects on the rabbit crosses carcass parameters. Comparable results were also noted by Nuamah *et al*., (2019), where they found no significant differences in all parameter assessed as far as primal cut-up parts of rabbit crosses carcass were concerned. Another study by Fadare (2015), indicated that the New Zealand breed crosses had the highest fore parts weight followed by Californian breed with no significant differences in thorax parts, with genetic origin influencing the dressing out percentage.

In respect to carcass parts, the results were similar with those of Macias-Fonseca *et al*. (2021), who found that loin and legs, were representing 16% and 24% of the carcass, respectively considering that they were of the most economical importance of the carcass.

Meat bone ratio of rabbit crosses carcass

The meat-to-bone ratio of rabbit carcasses was calculated using the weights of the hind leg flesh and bone. According to Ludwiczak *et al.,* (2016), muscle and bone from the rear legs is a good predictor. The meat-to-bone ratio did not differ significantly between rabbit carcass crosses ($p>0.05$). This is in line with Ouyed *et al.,* (2011), who found that the cross breeds had a somewhat higher meat-to-bone ratio, 5:5.3.

Influence of domestic rabbit breed crosses on the organoleptic properties of rabbit meat

The effect of breed on organoleptic traits was assessed. The ranking of the colour, flavor, tenderness, juiciness, texture as well as acceptability of meat from New Zealand cross with other breeds was not significant irrespective of general acceptability ranked high in NZW*Sf. Initial selection of meat by consumer is basically through colour which is highly and mainly related to myoglobin pigments concentration and its chemical state on the meat surface. Additionally, pigmentation dictates the muscle proteins structure and physical state (Apata *et al*., 2012; Fadare, 2015). The findings were in line with those of Fadare (2015), who found no outstanding significant difference in rabbit meat colour from crosses of New Zealand white with Californian rabbits, Havana black rabbits and Palomino rabbits. The chemical state of myoglobin according to Apata *et al*., (2012), is responsible for meat colour which is directly affected by cofactors and presence of substrates, the concentration of pH, partial pressure of O_2, tissue structure, temperature, light, lipid oxidation and the activity of reducing enzymes. According to Fadare (2015), weight and food restrictions of rabbits at a certain age greatly influences on quality of rabbit meat directly influencing consumer acceptability.

Daszkiewicz & Gugołek (2020), added that meat quantity and quality can also be influenced by production system such as either intensive or extensive. (Fadare, 2015), in addition pointed out that pH, as well as tenderness influence color of rabbit meat. In another study, a cross between New Zealand white and Palomino brown produced meat with least flavor (Fadare, 2015).

Results established insignificant differences in meat flavor among the rabbit crosses. This could have been influenced by the fact that all the crosses were under the same production management system. The findings agrees with those of (Fadare, 2015) who highlighted non-significant difference on the flavor of rabbit meat among crosses using meat from New Zealand white male rabbits and Palomino brown female crosses.

The findings showed insignificant difference in meat tenderness. According to Bízková & Tůmová (2010), tenderness of the meat is one of the most important sensory and physical characteristics of rabbit meat. Postmortem changes affecting proteins such as myofibrillar on the connective tissue that is responsible for meat toughness and tenderness. In addition, just like meat color, tenderness is also influenced by pH, as well as stress during slaughter (Ballan *et al*., 2022; Nuamah *et al*., 2019). According to Fadare (2015), both colour, tenderness and flavor as organoleptic characteristics of domestic rabbit meat can moderately be influenced by rabbit genetic type. They added that in order of preference, Havana back meat followed by meat samples from Palomino brown rabbit as well as New Zealand white with the most tender with Californian breed recording the least ranking.

For juiciness, all the rabbit breed crosses assessed in this research recorded similar level of juiciness. Ballan *et al*. (2022) and Nuamah *et al*. (2019) recorded that New Zealand white male rabbit and other breeds female crosses meat were alike in juiciness and texture as well as colour. They also added that small amounts of intramuscular fat, lubricate the muscle fibers, thus affecting juiciness and flavor of rabbit meat.

The results indicated non-significant difference in rabbit meat texture of the meat samples from different rabbit crosses. Meat texture according to Bízková & Tůmová, (2010) mainly and highly depends on the rabbit meat slaughter changes as well as on the structure of the meat muscle. Texture dictated how hard or soft the meat is. Hard meat is linked with higher collagen level and low amounts of fats as compared to soft meat. The findings disagrees with those of Fadare (2015) who indicated high levels of texture in new Zealand breed crosses as compared with that of Californian. Fadare (2015), in addition highlighted the effect of genotype on the rabbit meat texture confirming no significant effect.

The research established an overall acceptability of domestic rabbit meat. According to Omojola & Adesehinwa (2006), the acceptability of any livestock meat is dependent on both processing method and general qualities which can be physical, chemical or organoleptic The findings are in line with those of Fadare (2015), that there is no significant difference in rabbit meat overall acceptability among new Zealand rabbit breed meat. According to, Apata *et al*. (2012) sex may influence organoleptic properties of rabbit meat with male rabbit meat samples having better flavour, meat colour, juiciness, tenderness and texture. In another study rabbit meat organoleptic characteristics assessment, a high positive correlation was noted between flavour (Bízková & Tůmová, 2010) and juiciness (Fadare, 2015) in rabbit meat samples from new Zealand crosses was recorded. Other studies from various scholars highlighted positive correlation between organoleptic traits and overall acceptability (Apata *et al*., 2012; Fadare, 2015; Omojola & Adesehinwa, 2006).

Conclusion

The findings indicated that various carcass characteristics weights including; dressed head, live weight, fasting loss, weight after bleeding, edible parts, dressed head, giblet, total edible parts, hot carcass, dressing yield, carcass, carcass with giblet, carcass with giblet and inedible parts, blood, pelt, feet and tail, spleen, lungs and trachea, gastral intestinal tract full, total inedible parts, inedible parts of head, weight before fasting was not significantly different across the rabbit crosses. This could be due to the fact that the rabbits were kept in the same environment, fed with the same amount and type of feeds. Primal cuts ups parts of rabbit crosses carcasses did not differ significantly among the crosses. This could be explained by the fact that environment in which the crosses were brought up in was the same. The ranking of the flavor, tenderness, juiciness, texture, colour as well as acceptability of meat from New Zealand cross with other breeds was not significant irrespective of general acceptability ranked high in NZW*Sf. Crossing New Zealand parental breed rabbits with other breeds resulted in improved reproductive performance and viability in terms of litter size at birth and weaning. When New Zealand is utilized as the parental breed, the results on the productive behavior of the crosses progeny show that they are superior, with higher weekly weight growth and better feed conversion, though not substantially different.

Recommendations

This study has shown that genotype significantly influence body weight of rabbits both at the pre-weaning and post weaning stages. The research recommends more work to be done to establish if factors such as environmental conditions, diseases, feeding regimes as well as housing structures contributes significantly to body weight differences in rabbits both at the pre-weaning and post weaning stages.

Research also assessed various carcass characteristics weights including; live weight, fasting loss, weight after bleeding, carcass with giblet and dressed head, inedible parts, blood, pelt, feet and tail, spleen, lungs and trachea, gastro-intestinal tract full, inedible parts of head and total inedible parts among others in different domesticated rabbit crosses only. More work needs to be done to compare the rabbit crosses with pure breed in terms of carcass characteristics. Additionally, effects of feed distribution mode, management, gender and age need to be tested to ascertain their influences in carcass characteristics.

The ranking of the flavor, tenderness, juiciness, texture, color as well as acceptability of meat from New Zealand cross with other breeds was tested and found to be insignificant across the domesticated rabbit breed crosses. More work needs to be done to compare the crosses meat organoleptic characteristics with those of pure breed.

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